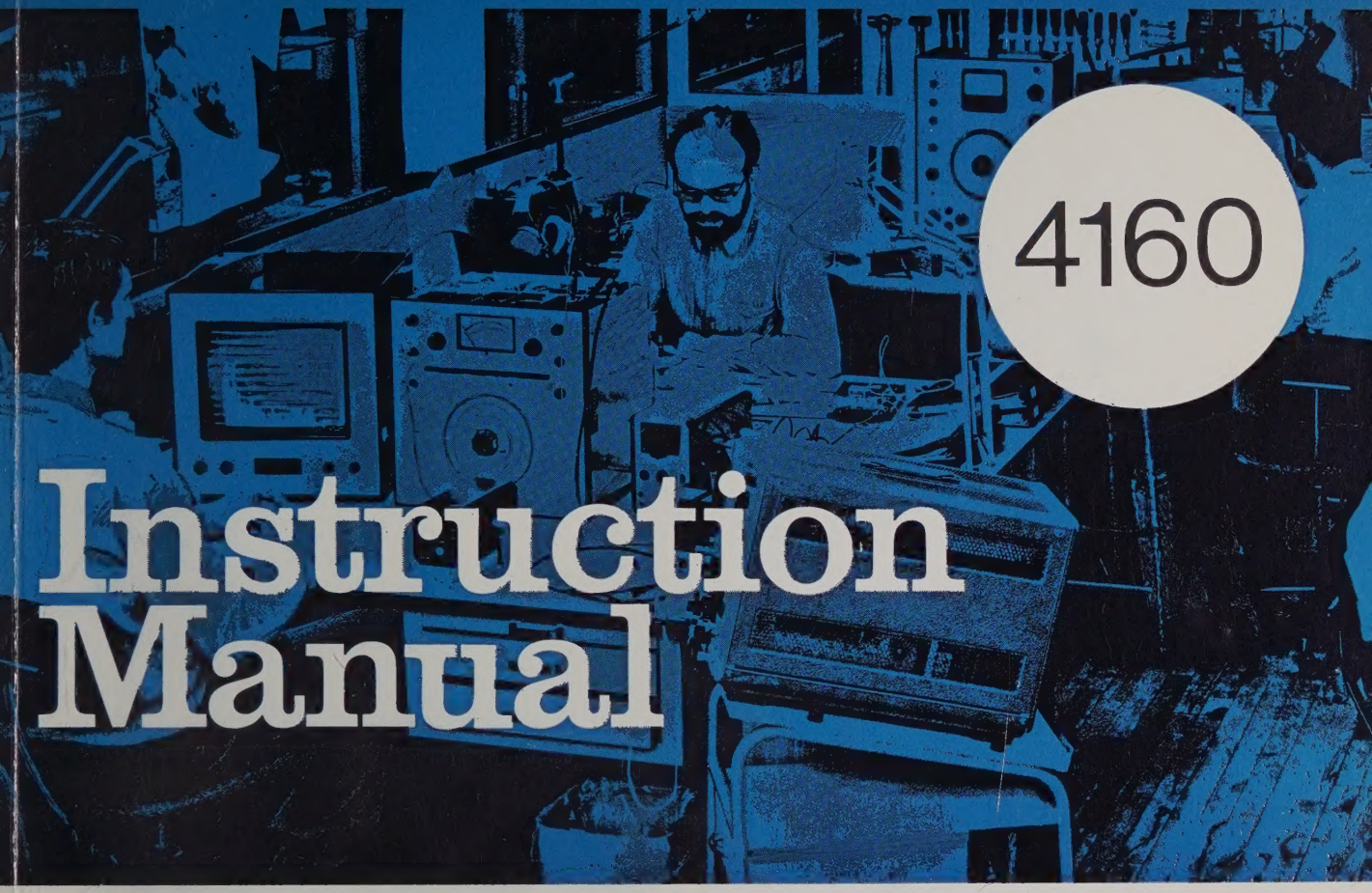

4160

Instruction Manual

One-Inch Condenser Microphone Type 4160

A high-stability precision condenser microphone, primarily intended for coupler measurements such as reciprocity calibration. Nominal sensitivity: —26,5 dB re 1 V/Pa with 200 V polarization. The microphone is designed as a laboratory standard and features the normalized front cavity. Each microphone is individually calibrated.

Brüel & Kjær

033-0168

ONE-INCH CONDENSER MICROPHONE
TYPE 4160

Reprint September 1976

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1. INTRODUCTION

The Condenser Microphone Type 4160 is a one-inch pressure microphone primarily intended for use in coupler measurements. This cartridge is equivalent to the Western Electric condenser microphone WE 640 A. It features the standardized front cavity for coupler measurements as specified in IEC R 327 and 402 and ANSI S1.10-1966, and the cartridge is back-vented to ensure that the gas in the coupler does not penetrate the cavity of the microphone. The adaptor ring providing the front cavity is permanently fixed in order to keep hydrogen leak to a minimum.

Besides the above-mentioned features, the 4160 is very similar to the well-known B & K Type 4144. The nominal sensitivity at 250 Hz is —26,5 dB re 1 V/Pa with 200 V polarization and the frequency range (± 1 dB) is 4 Hz to 8 kHz. Each cartridge is individually calibrated and is delivered with a calibration chart giving all important data, including a frequency response curve showing the true pressure response.

The present manual does not review the well-known principles of the condenser microphone, which may be found in the B & K Handbook "Microphones and Microphone Preamplifiers", but presents the specific characteristics of the 4160.

One Condenser Microphone Type 4160 is delivered with the B & K Reciprocity Calibration Apparatus Type 4143.

2. CONSTRUCTION

The 4160 is very similar to the well-known B & K Type 4144. The two basic differences are:

a) Built-in front cavity for coupler measurements to IEC R327 and 402, and ANSI S1.10-1966.

b) Back-venting of the cartridge.

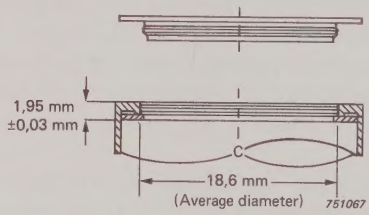


Fig.2.1. Adaptor ring providing the standardized front cavity. The adaptor ring is permanently fixed on the 4160 and cannot be removed

The front cavity (see Fig.2.1) is 1,95 mm deep. The mean diameter of the thread for the protection grid is 18,6 mm. This results into a nominal front volume of 530 mm^3.

The adaptor ring providing the front cavity is permanently fixed on the 4160. This ensures a very low diffusion of gas out of the coupler under measurements where the cavity is filled with a gas other than air, e. g. hydrogen.

Back-venting of the cartridge ensures that the gas in the coupler (if it is not air) does not penetrate the cavity of the microphone.

The 4160 fulfils the requirements of the American standard ANSI S1.12-1967 "Specifications for Laboratory Standard Microphones", Types L and XL. The external diameter of the cartridge is 23,77 mm ± 0,05 mm and the thread for preamplifier mounting is 23.11-60 UNS.

3. OPERATION

3.1. PRELIMINARY CONSIDERATIONS

The 4160 is supplied in a mahogany case containing the Microphone and its individual calibration chart. A cap containing silica gel is fitted over the back of the cartridge. This cap prevents humidity from penetrating the cartridge and should be replaced after measurements.

The following general considerations should be observed:

1. Only use finger torque to tighten threads.

2. Keep dust and foreign objects from the microphone diaphragm.

On no account should the diaphragm come into contact with fingers or any other objects. Should the diaphragm become contaminated by liquid, dust or oil, it may be wiped off with cotton cool or a very soft paint-brush, using the greatest care possible. The diaphragm will not normally corrode. If the diaphragm is slightly contaminated, the influence on the frequency response will be negligible. However, if the contamination results in a relatively large increase in mass, the frequency response will be modified at high frequencies.

3.2. MOUNTING

Many coupler measurements require the microphone to be mounted on a socket with a reference ground-shield configuration as defined in IEC R327 and 402, and ANSI S1.10-1966.

When the microphone is used as a transmitter, the reference ground shield is provided by the TRANSMITTER MICROPHONE SOCKET of the B & K Reciprocity Calibration Apparatus Type 4143. If the microphone is used as a receiver, use should be made of the one-inch Microphone Preamplifier Type 2627, which provides the reference ground shield and offers an insert-voltage facility. See the B & K Handbook "Microphones and Microphone Preamplifiers".

When the microphone is mounted on the relevant socket, remove the protection grid. For an airtight seal with the coupler, spread a little grease on the front ring of the microphone.

Note that the 4160 may be used with other preamplifiers, such as Type 2619 with Adaptor DB 0375, but in such a case the preamplifier input is not in accordance with the reference ground shield.

After measurements, replace the protection grid and fit the protective cap over the back of the cartridge.

3.3. CALIBRATION

The 4160 is factory-calibrated and the calibration data given by the calibration chart will normally remain valid indefinitely. However, the 4160 will often be used as a laboratory standard, and thus will require periodic checks of the sensitivity, for instance using the reciprocity technique. For this purpose, the B & K Reciprocity Calibration Apparatus Type 4143 is available. This instrument (shown in Fig.3.1) allows fast, easy measurement of the sensitivity products using a built-in precision attenuator. An extensive range of accessories is supplied, including two IEC Couplers, a one-inch Microphone Preamplifier Type 2627 and one 4160. The 4143 also allows insert-loss compensation. Full details of the 4143 may be found in its Instruction Manual.

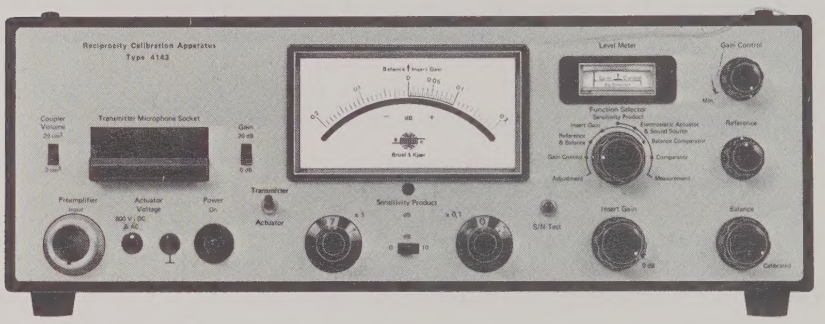


Fig.3.1. The Reciprocity Calibration Apparatus Type 4143

For fast calibration of a measuring system, use can be made of a Pistonphone Type 4220. It operates at 250 Hz and delivers a sound pressure level of 124 dB with an accuracy of ± 0,2 dB. The instrument is factory-calibrated and delivered with individual calibration data.

It should be noted that the 4160 does not load the Pistonphone in the same way as other B & K one-inch microphones with protection grid. For a 4160 without protection grid, the sum of the front volume and equivalent volume is 0,670 cm^3 (nominal), whereas it is 1,33 cm^3 for the other microphones. This results in an increase in sound pressure level of 0,3 dB. With the protection grid fitted, the increase is 0,42 dB. This correction should be added to the value indicated on the calibration chart of the Pistonphone, together with the correction for static pressure, if any. See Instruction Manual for Type 4220 (section 2.3).

Use can also be made of the Sound Level Calibrator Type 4230 which delivers 94 dB SPL at 1000 Hz, with an accuracy of ± 0,3 dB. The equivalent volume of the Calibrator is very large (> 200 cm^3 at 25°C) and no volume correction is necessary in this case. For more details, reference should be made to the 4230 Instruction Manual.

3.4. SENSITIVITY

The sensitivity indicated on the calibration chart is the open-circuit sensitivity, S_o. The actual sensitivity S_1, when the cartridge is loaded by a preamplifier, may be derived from:

$$S_1 = S_o \times A \times \frac{C_t}{C_t + C}$$

where A = voltage gain of the preamplifier
C_t = cartridge capacitance
C = input capacitance of the preamplifier

Many B & K instruments are calibrated for a standard microphone sensitivity of 50 mV per pascal, i. e. —26 dB relative to 1 V per pascal. Since the microphone, or microphone plus preamplifier, may differ from this sensitivity, a correction factor must be added to the meter reading of these instruments to get the actual level. In other words, the sound level in dB measured by an instrument calibrated to a 50 mV per pascal standard microphone sensitivity is equal to the meter reading of the instrument plus the attenuator setting, if any, plus the correction factor K. K is the correction factor for the combination of microphone plus preamplifier and includes K_o, the correction factor of the microphone alone, which is given on the calibration chart supplied with the microphone.

$$K = K_o - G$$

where G is the absolute value of the gain of the preamplifier in dB and includes the effect of transducer capacitance.

On the back of the calibration chart supplied with each microphone is a table of some of the typical gains of various B & K preamplifiers.

4. FACTORY CALIBRATION

Before leaving the factory, each microphone cartridge is submitted to an extensive ageing and calibration procedure. Before starting the ageing procedure, the microphone sensitivity is checked and adjusted to a lower value than the nominal sensitivity, since sensitivity will be increased by the ageing procedure. After ageing the microphone is submitted to a full calibration procedure. All important parameters are individually measured and indicated on the calibration chart together with the frequency response (see Fig.4.1).

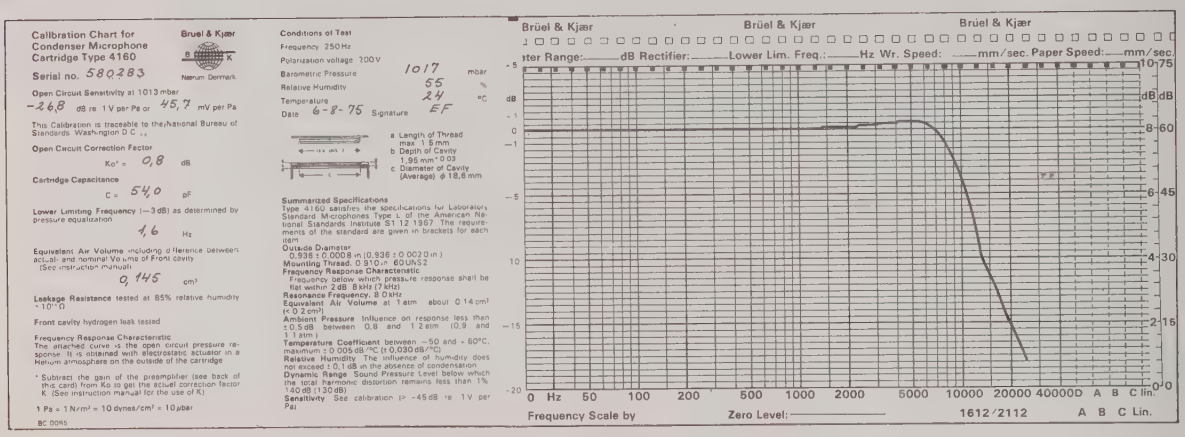

Calibration Chart for
Condenser Microphone
Cartridge Type 4160
Bruel & Kjær
Serial no. 580283
Nærum Denmark
Open Circuit Sensitivity at 1013 mbar
−26,8 dB re 1 V per Pa or 45,7 mV per Pa
This Calibration is traceable to the National Bureau of Standards Washington D C
Open Circuit Correction Factor
Ko' = 0,8 dB
Cartridge Capacitance
C = 54,0 pF
Lower Limiting Frequency (−3 dB) as determined by pressure equalization
1,6 Hz
Equivalent Air Volume including difference between actual and nominal Volume of Front cavity
(See instruction manual)
0,145 cm³
Leakage Resistance tested at 85% relative humidity
Front cavity hydrogen leak tested
Frequency Response Characteristic
The attached curve is the open circuit pressure response It is obtained with electrostatic actuator in a Helium atmosphere on the outside of the cartridge
* Subtract the gain of the preamplifier (see back of the card) from Ko to get the actuel correction factor K (See instruction manual for the use of K)
1 Pa = 1 N/m² = 10 dynes/cm² = 10 μbar
BC 0085
Conditions of Test
Frequency 250 Hz
Polarization voltage 200 V
Barometric Pressure 1017 mbar
Relative Humidity 55 %
Temperature 24 °C
Date 6-8-75 Signature EF
a Length of Thread max 1,5 mm
b Depth of Cavity 1,95 mm ± 0,03
c Diameter of Cavity (Average) ϕ 18,6 mm
Summarized Specifications
Type 4160 satisfies the specifications for Laboratory Standard Microphones Type L of the American National Standards Institute S1.12 1967. The requirements of the standard are given in brackets for each item
Outside Diameter
0,936 ± 0,0008 in (0,936 ± 0,002 in)
Mounting Thread 0,910-60 UNS-2
Frequency Response Characteristic
Frequency below which pressure response shall be flat within 2 dB 8 kHz (7 kHz)
Resonance Frequency, 8 0 kHz
Equivalent Air Volume at 1 atm about 0 14 cm³ (± 0 2 cm³)
Ambient Pressure Influence on response less than ± 0,5 dB between 0,8 and 1 2 atm (0,9 and 1 1 atm)
Temperature Coefficient between −50 and + 60°C, maximum ± 0 005 dB /°C (± 0,030 dB/°C)
Relative Humidity The influence of humidity does not exceed ± 0,1 dB in the absence of condensation
Dynamic Range Sound Pressure Level below which the total harmonic distortion remains less than 1% 140 dB (130 dB)
Sensitivity See calibration (= −45 dB re 1 V per Pa)
Brüel & Kjær
Brüel & Kjær
Brüel & Kjær
Range: dB Rectifier: Lower Lim. Freq.: Hz Wr. Speed: mm/sec. Paper Speed: mm/sec
dB
0 Hz 50 100 200 500 1000 2000 5000 10000 20000 40000D A B C lin.
Frequency Scale by
Zero Level:
1612/2112
A B C Lin.

Fig.4.1. Typical calibration chart as supplied with each 4160

4.1. SENSITIVITY

The open-circuit sensitivity, which is the sensitivity when the microphone is not loaded by any preamplifier, stray capacitance, etc., is measured at 250 Hz by comparison with a standard microphone using insert-voltage technique and a specially-developed pistonphone. In order to minimize the effect of production variations in microphone equivalent (and front) volume, the internal volume of the pistonphone is twice that of the Pistonphone Type 4220. Since other dimensions of the calibration pistonphone are similar to those of the 4220, calibration level is 118 dB.

For the calibration, the protection grid of the 4160 is removed. The standard microphones used for the comparison (Type 4144 with Adaptor Ring DB 0111) are calibrated once a year using the reciprocity calibration method in agreement with IEC Recommendation 327 (accuracy better than 0,05 dB). They are also checked by external authorities.

4.2. CARTRIDGE CAPACITANCE

The capacitance indicated on the calibration chart is measured at 250 Hz with the nominal polarization voltage (200 V DC).

4.3. FREQUENCY RESPONSE

Since the 4160 is designed for coupler measurements, the frequency response given by the calibration chart is the microphone pressure response which, at higher frequencies, differs from the actuator response in air due to different acoustical loading of the microphone.

The set-up for recording the frequency response of the 4160 is shown in Fig.4.2. The microphone diaphragm is placed in a helium atmosphere, but venting of the microphone is such that the microphone cavity remains filled with air. The BFO OUTPUT of the Heterodyne Analyzer Type 2010 is connected to the OSCILLATOR INPUT of the Reciprocity Calibration Apparatus Type 4143. The DC component of the excitation signal delivered by the 4143 must be lower than that for normal electrostatic actuator measurements (i.e. below 400 V) in order to avoid arcing. The excitation signal drives a specially-designed electrostatic actuator. The distance between the actuator grid and the microphone diaphragm is slightly greater than normal (0,8 mm instead of 0,5 mm).

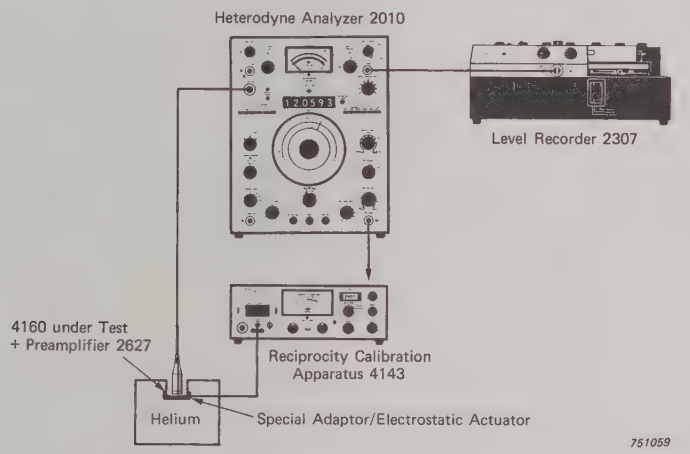


Fig.4.2. Set-up for recording the frequency response of the 4160

4.4. LOWER LIMITING FREQUENCY

The lower limiting frequency (—3 dB) of the 4160 is individually calibrated and indicated on the calibration chart.

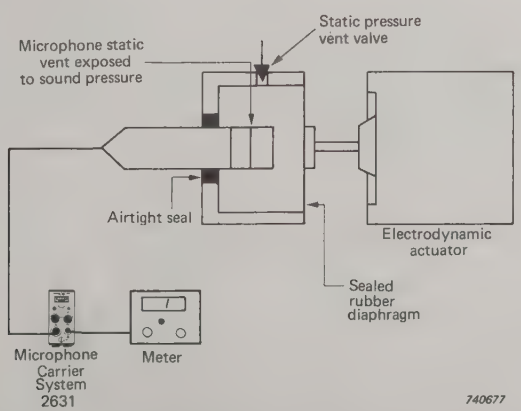


Fig.4.3. Set-up for measuring the lower limiting frequency of the 4160

The equipment used in the factory calibration of lower limiting frequency is shown in Fig.4.3. The microphone is placed inside a sealed coupler and provided with a pressure signal at constant level and variable low frequency by an electrodynamic transducer. The output of the test microphone is observed on a meter on the output of the 2631 Microphone Carrier System which is connected to the test microphone. The test frequency is reduced until the meter indicates a level drop of 3 dB from the high frequency output. A monitoring microphone (whose static pressure equalization vent is not exposed to the low frequency pressure variation, and is therefore effectively sealed) ensures a constant pressure level inside the coupler.

4.5. EQUIVALENT VOLUME

The microphone equivalent volume indicated on the calibration chart is the difference between the measured equivalent and front volume and the nominal front volume (530 mm^3).

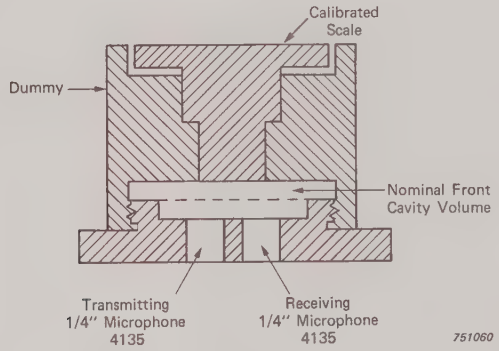


Fig.4.4. Coupler used for factory calibration of the equivalent volume of the 4160

Measurement is made using a special coupler shown in Fig.4.4. A quarter-inch condenser microphone Type 4135 is used as a sound source while the resulting sound pressure is measured by another 4135. The 4160 is first placed onto the top of the coupler and the excitation signal of the transmitter microphone is adjusted until the output of the receiver microphone is equal to a chosen reference value.

The 4160 is then replaced by an adjustable dummy. The calibrated centre screw is adjusted until the output of the receiver microphone is again equal to the reference value. From the reading on the calibrated scale of the dummy, the equivalent volume of the microphone is derived, taking into account heat conduction so that the equivalent volume indicated on the calibration chart refers to purely adiabatic conditions.

5. CHARACTERISTICS

5.1. SENSITIVITY

The open-circuit sensitivity of a microphone is the sensitivity of the cartridge when it is not loaded by a preamplifier, stray capacitance, etc. The open-circuit sensitivity of the 4160 is nominally 47,5 mV/Pa (—26,5 dB re 1 V/Pa). Each cartridge is individually calibrated and the actual value is given by the calibration chart. See section 4.1.

When the cartridge is loaded by a preamplifier, a slight reduction in sensitivity can be expected, but this may be compensated for by the insert voltage technique when using a Preamplifier Type 2627.

5.2. FREQUENCY RESPONSE

The calibration chart of the 4160 gives the individual pressure frequency response (see section 4.3). The nominal frequency response (± 1 dB) is 4 Hz to 8 kHz. The lower limiting frequency (—3 dB) is also individually calibrated (see section 4.4) and lies between 1 Hz and 2 Hz.

5.3. DYNAMIC RANGE

The lower limit of the dynamic range is determined by the electrical noise of the preamplifier or noise due to thermal agitation in the diaphragm. With the 4160 fitted to a Preamplifier Type 2627, the noise floor is equivalent to 23 dB(lin.) or 13 dB(A).

The upper limit of the dynamic range for 3% distortion is 146 dB. It is recommended that the microphone be not exposed to sound pressure levels higher than 160 dB.

5.4. PHASE CHARACTERISTICS

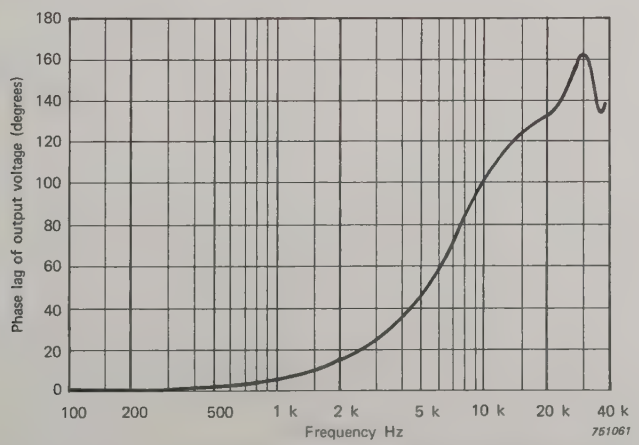


Fig.5.1. Typical phase response of the 4160

As with all B & K microphones, the positive polarization voltage on the backplate means that the output signal from the preamplifier will be positive-going for a negative-going sound pressure on the microphone diaphragm at low frequencies. The phase response of the 4160 is shown in Fig.5.1. The resonance frequency of the microphone is defined by a phase lag of 90°.

5.5. EQUIVALENT VOLUME

The 4160 being designed mainly for coupler measurements, its equivalent volume is of importance, as well as the front volume. When the microphone diaphragm is part of the boundary of a cavity, the diaphragm does not act as a rigid wall, but moves due to the sound pressure. This makes the coupler volume appear larger than it really is up to the resonance frequency of the microphone (above which the incremental volume becomes negative). This increment in cavity volume due to the microphone is known as the equivalent volume of the microphone.

The driving-point impedance of the microphone (the ratio of the uniform sound pressure over the diaphragm to the volume velocity of the diaphragm) can be expressed in terms of the equivalent volume V_e. V_e is thus defined:

$$V_e = \frac{\gamma P}{j\omega Z_a}$$

where
- γ = ratio of specific heats of the gas in the coupler
- P = ambient pressure
- Z_a = acoustic driving-point impedance
- ω = angular frequency (= $2\pi f$)

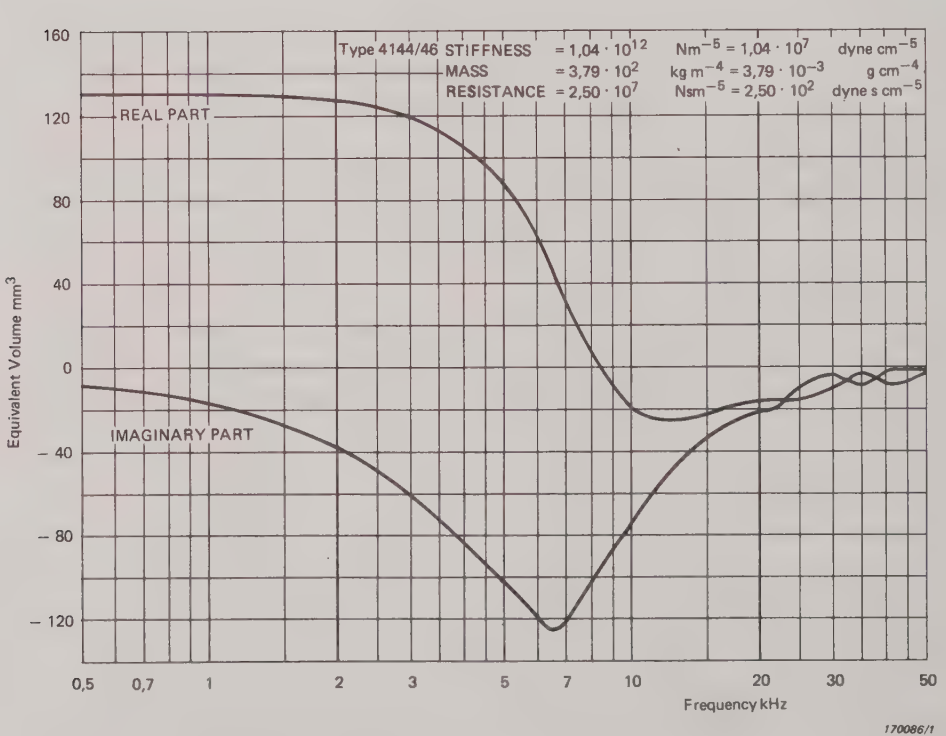


Fig.5.2. Variation of equivalent volume with frequency

The method used at Brüel & Kjær for measuring the equivalent volume of the 4160 is described in section 4.5. The nominal equivalent volume is 140 mm^3 at 250 Hz and typical equivalent volume curves as a function of frequency are shown in Fig.5.2.

5.6. CAPACITANCE

The microphone cartridge capacitance with 200 V polarization is measured for each individual cartridge at 250 Hz and is quoted on the calibration chart. The nominal value for Type 4160 is 55 pF.

Due to the non-linearity of electromechanical coupling and to the effects of the diaphragm movement, however, the capacitance of the polarized cartridge varies slightly with polarization voltage and with frequency. This is illustrated in Fig.5.3 for different polarization voltages.

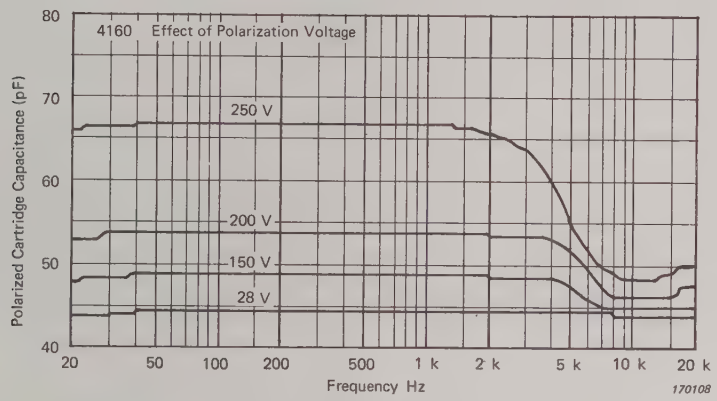


Fig.5.3. Variation of capacitance with frequency

5.7. POLARIZATION VOLTAGE

The 4160 is designed for operation with a DC polarization voltage of 200 V. The maximum polarization voltage which may be applied is 250 V. Any voltage greater than this may damage the microphone.

Sensitivity variation at 250 Hz as a function of polarization voltage is given in Fig.5.4, while variation of frequency response (measured using the set-up described in section 4.3) is shown in Fig.5.5. This variation is due mainly to the change in distance

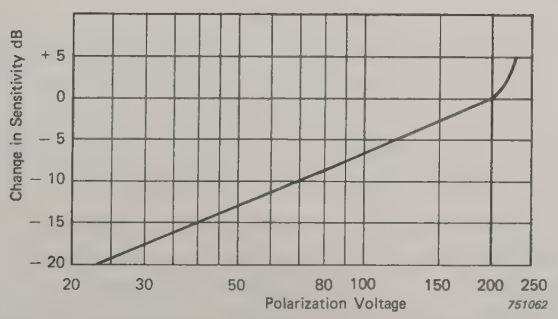


Fig.5.4. Sensitivity variation with polarization voltage

between the diaphragm and backplate of the microphone, which affects the damping of the diaphragm motion around resonance.

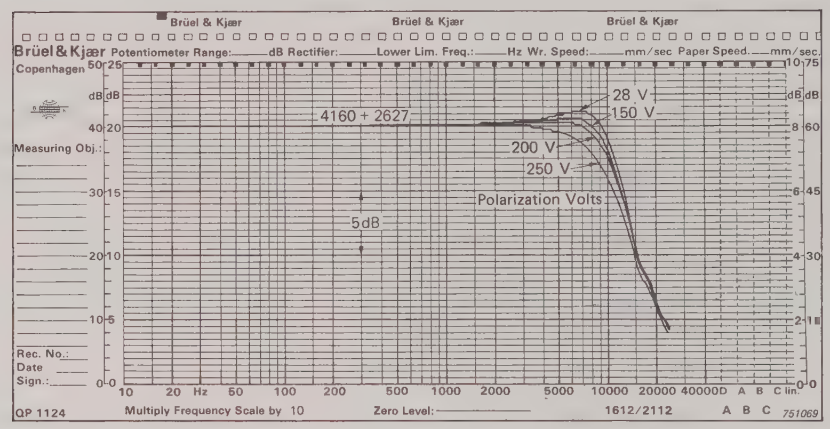


Fig.5.5. Frequency response variation with polarization voltage

5.8. HYDROGEN LEAK OF FRONT CAVITY

In coupler measurements, it is common practice to fill the cavity with hydrogen in order to extend its useful frequency range. It is important in such cases that the hydrogen leak is kept to a minimum. Regarding contact surfaces between the coupler and the microphone adaptors, a little grease provides satisfactory sealing, and it is therefore important that the leak of the front cavity is as low as possible.

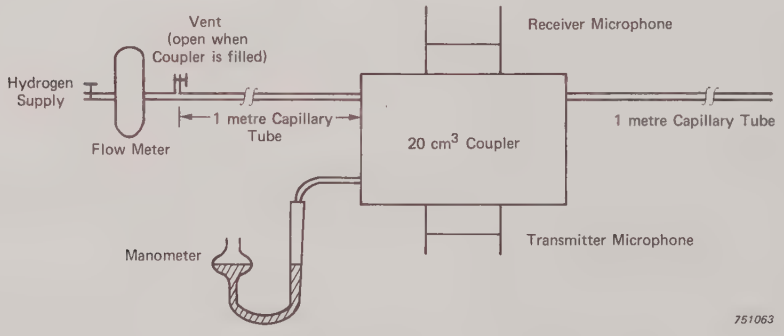


Fig.5.6. Set-up used for checking hydrogen leak

For Type 4160, the set-up of Fig.5.6 is used to estimate the hydrogen leak of the front cavity. A 20 cm^3 coupler is filled with hydrogen via a one-metre long capillary tube (inner diameter 0,31 mm). The cavity is vented by another capillary tube of same length and diameter. A manometer allows checking that the static pressure inside the cavity is the same as atmospheric pressure. Note that the gas supply system does not include buffers.

The transmitter microphone is a specially-tested 4160 which has shown remarkable airtightness, while the receiver microphone is the 4160 under test.

When the coupler is completely filled with hydrogen, the signal to the transmitter microphone is tuned to the coupler resonant frequency, the gas supply is stopped, and a vent

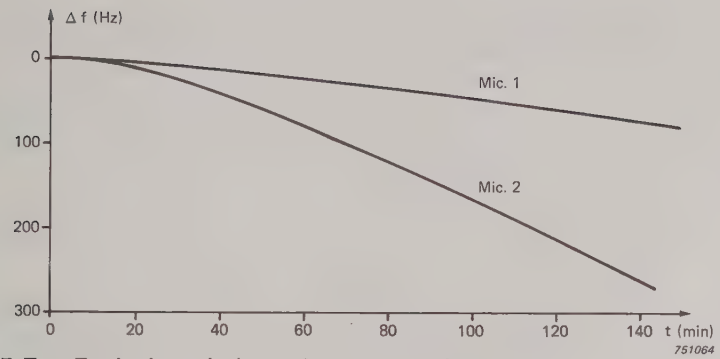


Fig.5.7. Typical variation of resonant frequency due to hydrogen leak

of the input tube is opened. A hydrogen leak is indicated by the lowering of the resonant frequency in the coupler, as shown in Fig.5.7. With the 4160, the lowering of the resonant frequency is less than 3% per hour.

5.9. LEAKAGE RESISTANCE

For precision measurements the leakage resistance of a condenser microphone must be at least 1000 to 10000 times higher than the resistance in the charging circuit of the preamplifier. This is to be sure that loading of the polarization voltage source does not cause any reduction of the actual polarization voltage at the microphone cartridge. Usually, the charging resistance is between 10^8 and 10^9 Ω, so the leakage resistance of the cartridge must be above 10^{12} Ω.

The insulator is pure quartz which has been treated with silicon to eliminate humidity problems. The construction used makes this part of the cartridge non-critical. The main leakage path is normally due to ion current across the air gap between the diaphragm and back plate. Advanced cleaning and polishing techniques give the high reliability of the high leakage resistance. This resistance is verified in the manufacturing process to be higher than 5×10^{15} Ω at 52% relative humidity.

5.10. LONG-TERM STABILITY

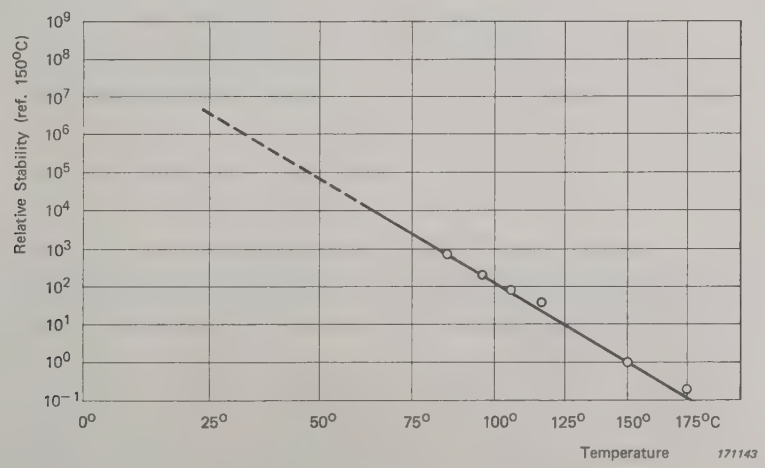


Fig.5.8. Long-term stability

The sensitivity of a microphone will increase slightly over a long period of time even if no mishandling or damage has occured. This change is due to creep of the diaphragm, so that a reduction of diaphragm tension takes place. The rate of change of sensitivity is greater at elevated temperatures and at 150°C the rate of change is specified to be better than 1 dB per two hours. Variation of the stability as a function of temperature is shown is Fig.5.8. By extrapolation to room temperature, this gives a stability of the order of 1 dB per 900 years.

5.11. TEMPERATURE

As mentioned in section 5.10, operation at high temperature increases the rate of change in sensitivity. The smaller, reversible changes in sensitivity are shown in Fig.5.9 while Fig.5.10 shows the influence of temperature on the frequency response.

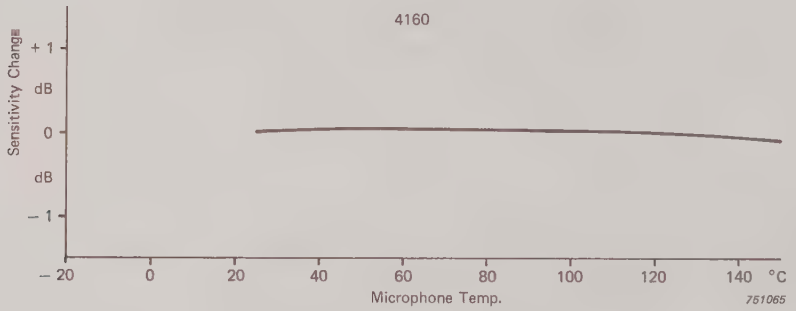


Fig.5.9. Sensitivity variation with temperature

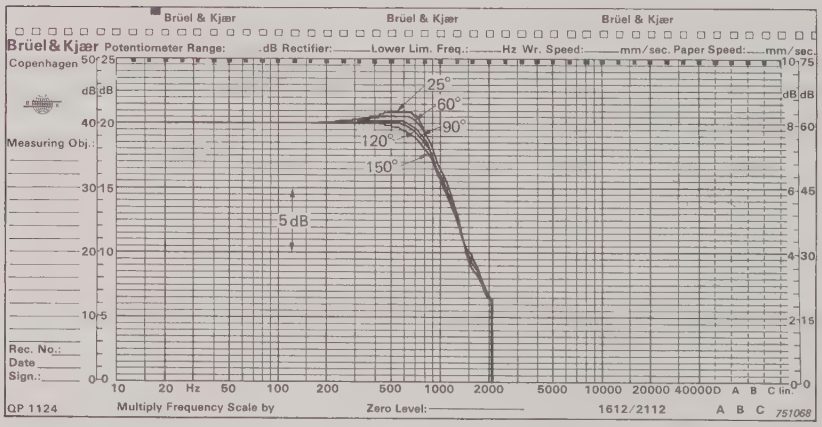


Fig.5.10. Frequency-response variation with temperature

The changes are the result of small expansions and contractions of the microphone materials, particularly the housing and the backplate which result in a change of the distance between the diaphragm and the backplate and in changes of diaphragm tension. The materials of the microphone have been chosen to give a thermal matching as close as possible to ideal. Consequently, the diaphragm tension and the distance between diaphragm and backplate are virtually independent of temperature.

The 4160 can be used continuously at temperatures within the range —50°C to + 150°C. The insulation of the preamplifier cable should not be exposed to more than

+ 100°C, and the preamplifiers themselves operate within the temperature range —20°C to + 60°C.

5.12. EFFECT OF AMBIENT PRESSURE

One important contributing factor to the stiffness of the vibrating system comes from the air inside the microphone. As the ambient air pressure decreases, so too does the stiffness, with the result that sensitivity of the microphone is determined mainly by stiffness. Around the resonance frequency, the response is almost entirely determined by the energy losses in the vibrating system. The mechanics of this dissipative system are very complicated, air viscosity being just one of the contributory factors.

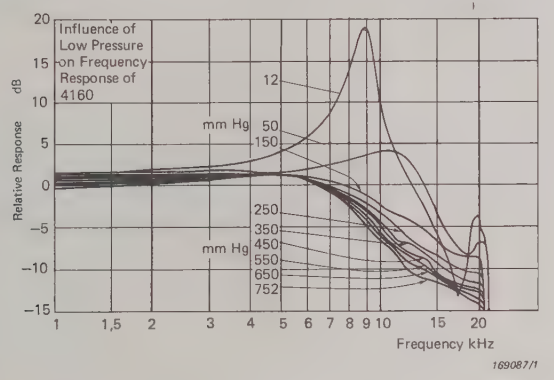


Fig.5.11. Frequency-response variation with ambient pressure

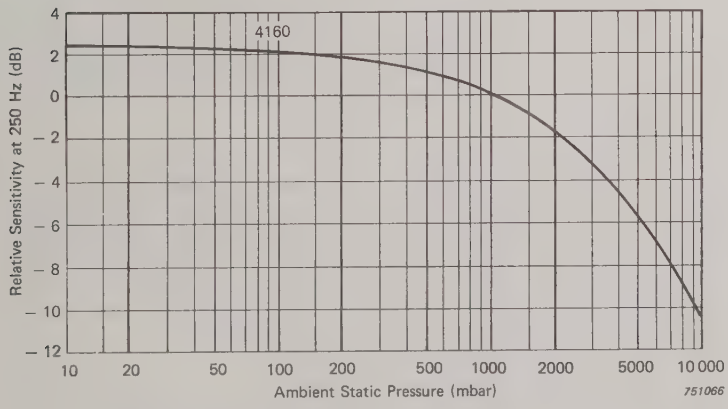


Fig.5.12. Variation of sensitivity at 250 Hz with ambient pressure

The effects of static pressure on frequency response are shown in Fig.5.11 while the variation with static pressure of sensitivity at 250 Hz is given in Fig.5.12.

5.13. EFFECT OF HUMIDITY

So long as condensation does not take place, the effect of high humidity on the microphone is negligible. However, once condensation has taken place, there is a temporary

risk of electrical noise because of intermittent short circuits of the diaphragm and backplate. It is recommended that power to the preamplifier be switched off when this occurs.

At delivery, the 4160 is fitted with a silica-gel cap over the rear of the cartridge. The cap should be fitted whenever the microphone is not in use. The silica-gel should be maintained in its dry (blue) state by placing it in a warm dry environment (not exceeding 135°C) whenever signs of pinkishness appear.

5.14. EFFECT OF VIBRATION

The influence of vibration is at a maximum when it is applied perpendicular to the diaphragm. Severity is determined mainly by the mass of the diaphragm and the air mass on both sides of it. With the 4160, an acceleration of 1 m/s^2 RMS perpendicular to the diaphragm produces an output equivalent to a sound pressure level of 68 dB re. 20 μPa.

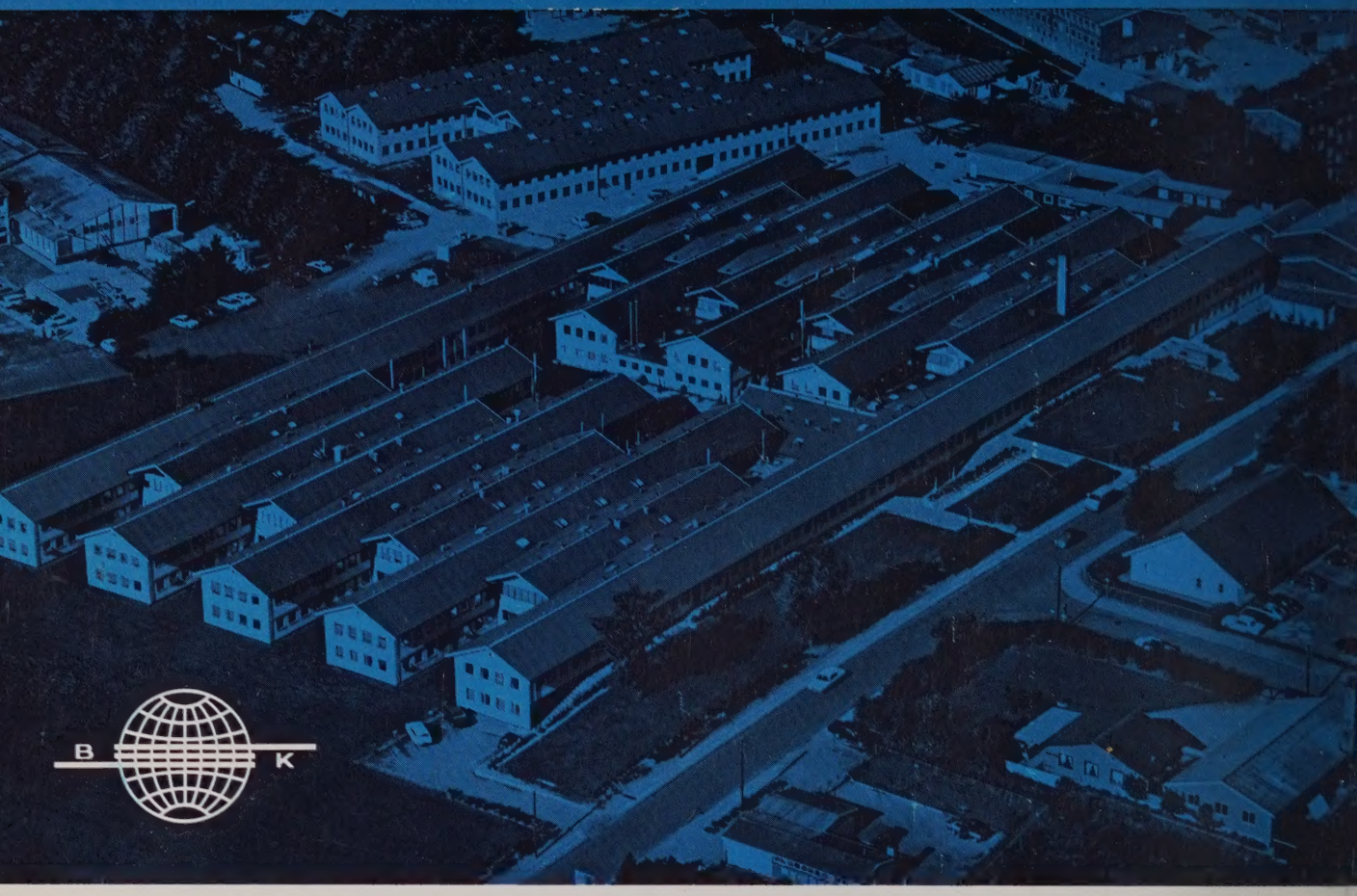
5.15. EFFECT OF MAGNETIC FIELDS

The influence of a magnetic field depends on its orientation to the diaphragm of the microphone. With a magnetic field of 100 A/m at 50 Hz in the direction which has most effect on the microphone, the equivalent sound pressure level is of 18 dB re. 20 μPa.

6. SPECIFICATIONS

Diameter:	23,77 ± 0,05 mm
Height:	
with Protecting Grid	19,30 mm
without Protecting Grid	18,95 mm
Thread for Preamplifier Mounting:	23,11 — 60 UNS
Polarization Voltage:	200 V
Open-Circuit Sensitivity* (250 Hz):	—26,5 dB ± 1 dB re 1 V/Pa 42 to 53 mV/Pa
Pressure Response* (± 1 dB):	4 Hz to 8 kHz
Lower Limiting Frequency* (—3 dB):	1 Hz to 2 Hz
Pressure-Equalization Time Constant:	0,16 s to 0,08 s The cartridge is back-vented
Resonant Frequency (90° phase shift):	8 kHz
Polarized Capacitance* (250 Hz):	55 pF ± 3 pF
Upper Limit of Dynamic Range (3% dist):	146 dB
Safety Limit:	160 dB
Equivalent Air Volume*:	140 mm^3 ± 30 mm^3
Influence of Ambient Pressure at 1013 mbar:	—0,002 dB/mbar
Temperature Coefficient:	Less than ± 0,005 dB/°C
Long Term Stability:	> 2 hours/dB at 150°C (900 years/dB at 23°C)
Vibration Sensitivity:	Approx. 88 dB for 1g
Insulation Resistance at 88% RH:	$> 10^{11}$ Ω
Hydrogen Leak of Front Cavity:	Δf_o < 3%/h in 20 cm^3 coupler without buffers (see section 5.8)

* Individually Calibrated (see Chapter 4)



BRÜEL & KJÆR instruments cover the whole field of sound and vibration measurements. The main groups are:

ACOUSTICAL MEASUREMENTS
Condenser Microphones
Piezoelectric Microphones
Microphone Preamplifiers
Hydrophones
Sound Level Meters
Precision Sound Level Meters
Impulse Sound Level Meters
Noise Dose Meters
Noise Level Analyzers
Standing Wave Apparatus
Calibration Equipment
Reverberation Processors
Sound Sources

ACOUSTICAL RESPONSE TESTING
Sine Generators
Random Noise Generators
Sine-Random Generators
Artificial Voices
Artificial Ears
Artificial Mastoids
Hearing Aid Test Boxes
Audiometer Calibrators
Telephone Measuring Equipment
Audio Reproduction Test Equipment
Tapping Machines
Turntables

VIBRATION MEASUREMENTS
Accelerometers
Force Transducers
Impedance Heads
Accelerometer Preamplifiers
Vibration Meters
Accelerometer Calibrators
Magnetic Transducers
Capacitive Transducers
Complex Modulus Apparatus
Bump Recorders

VIBRATION TESTING
Exciter Controls — Sine
Exciter Controls — Sine — Random
Exciter Equalizers, Random or Shock
Exciters
Power Amplifiers
Programmer Units
Stroboscopes

STRAIN MEASUREMENTS
Strain Gauge Apparatus
Multipoint Selectors

MEASUREMENT AND ANALYSIS
Voltmeters
Phase Meters
Deviation Bridges
Measuring Amplifiers
Band-Pass Filter Sets
Frequency Analyzers
Real Time Analyzers
Heterodyne Filters and Analyzers
Distortion Measuring Equipment
Psophometers
Statistical Distribution Analyzers
Tracking Filters

RECORDING
Level Recorders
Frequency Response Tracers
Tape Recorders
Alphanumeric Printers
Digital Event Recorders

DIGITAL EQUIPMENT
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Tape Punchers
Tape Readers

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